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Centrum voor de Studie van de Sierplantenteelt
Fakulteit van de Landbouwwetenschappen, Gent, België

The influence of salt concentration on the mite population in pine litter[1])

A. Heungens and E. van Daele

With one figure

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1. Introduction

Pine litter is one of the most frequently used substrates in the culture of indoor plants and azaleas in nurseries in the Ghent area of Belgium.

In order to obtain full development of the plants, fertilizers are added to the substrate. These fertilizers constitute a physico-chemical factor affecting considerably the success of the culture.

A poor development of the plants can be attributed to a too low application of fertilizers, but on the contrary an overdose can be responsible for the arrest of growth and eventually scorching. As fertilizers and salts can leach out, it is not possible to establish by means of chemical analysis if an overdose of fertilizers or dammage by salts were the original causes for a failure of the culture.

If elevated salt concentrations could be indicated by living organisms, the above mentionned inconvenience could be bypassed and thus the grower informed of the real cause of the dammage. In order to establish this we studied the effect of salt concentrations (as indicated by conductivity) on the mite fauna.

2. Literature

The data from some papers dealing with the influence of fertilizers on mite populations are contradictory. The fact that the biology of many mite species differs to a large extent can explain this contradiction. There should also be made a clear distinction between organic fertilizers constituting a source of nutrition to the saprophagic fauna and increasing the salt concentration only later, after mineralisation, and mineral fertilizers which do not immediately act as a source of nutrition but become as soon as applied an integral part of the salt concentration in the soil.

It has been established that in arable land some years after application of organic fertilizers, more mites were present in the treated than in the untreated plots (Sauerlandt & Marzusch-Trappman 1962; Höller 1962) although some specific species decreased in number. Heungens (1969) found in plots enriched with malt germ a higher number of gamasids than in those recieving only a single inorganic fertilizer; oribatids however did not differ. We do not attribute the increase of the gamasid population in the first place to the manuring but rather to the increase of populations of other groups, in particular the nematodes and enchytraeids, preyed upon by *Parholaspulus alstoni*, the dominant gamasid in this experiment. Another experiment (Heungens & van Daele 1979) confirmed the preceding observations, but the fluctuations were rather small. Primavesi & Covolo (1968) suggested that mites will not respond favourably to organic fertilizers due to their dislike for nitrogen. By contrast Kipenvarlic (1964) noted a significant increase of mite population after applications of an organic fertilizer.

The different data on this subject can be summarised as follows: after application of an organic fertilizer the humification process will start with a rapid increase of specific components of the microflora, these precede a whole series of changes in populations of microorganisms in interaction

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with one another (commensalism). Negative interactions will then appear (antagonism, predation, competition), resulting in pronounced changes in the population density, until the process of humification and mineralisation is complete. A period of temporary stabilisation then occurs.

In general after an application of an organic fertilizer in a mineral soil, an increase of the mite population may be expected. With mineral fertilizers one obtains a growth of both micro- and macroflora. The increase of mycelium in the soil is a source of nutrition to many saprophages, among which are many mite species. In this way a rise in the Acari fauna following an application of mineral fertilizer can easely be explained.

By adding nitrogen to the soil, many authors (Franz 1953; Müller 1957; Ronde 1957, 1959, 1960; Traitteur-Ronde 1961; Mayer-Krapoll 1963 and Weetman et al. 1972) noted an increase in the mite population, with the exception of the Oribatei. The composition of the nitrogen fertilizers is also of some importance. In this connection Franz (1957) and Moursi (1962) found that ammonia was toxic to mites. According to Carey et al. (1971) potash fertilizer enhanced the mite population. Höller (1962), Mayer-Krapoll (1963) and Haüsser et al. (1969) found that phosphorus gives analogous results.

Due to the diversity of the results obtained it is not clear which factors are responsible for the changes in the population density. Even Marshall's extensive review of the literature on the subject (1977) does not give a satisfactory explanation. We limited our research to the application of increasing doses of a compound mineral fertilizer. As such the problem can be simplified, and reduced to the results of the effect of the salt concentration on the mite fauna.

3. Materials and methods

Two different litter-types, fresh pine litter and a pine litter one year old, were taken from an azalea nursery. Both substrates were from *Pinus sylvestris* litter, and were cleaned from wood fragments and cones. One litter samples were then put in plastic containers (10 cm × 10 cm × 15 cm). Such substrates contain in general an elevated mite population, therefore the substrate were not enriched with additional organisms.

For the fresh pine litter the average weight was 116 g with standard deviation 14 g ($n = 40$) and for the one year old pine litter 148 ± 17 g. At the beginning of the experiment the weights in wet condition were respectively 289 ± 18 g and 383 ± 24 g. By weighing the plastic containers and contents regularly and adding some distilled water the weight and water content were kept relatively stable.

To the substrates a series of salt-concentrations 0 –0,2 –0,8 and 2 g per liter of substrate was added, corresponding with (for many ornamental plants) a range from very low to a too high conductivity.

The salt chosen was the fertilizer Alkrisal (18 –6 –12), this type being generally accepted as providing an appropiate NPK-ratio for azaleas.

For justification of the choice of the salt concentrations used refere to our previous publications, Heungens & Roos (1975) and Heungens et al. (1975). In the latter paper two methods for determining the conductivity (salt concentration) of a substrate are given. The conductivities of 4 grams air-dried substrate + 100 ml water and 100 ml normally wet substrate + 400 ml water were compared after 24 hours. The results proved that the conductivities for both methods are approximately the same for a pine litter substrate (although not for peat). In the present tests the second method was used.

The plastic containers prevented leaching of the salts and by closing them at given times the evaporation was held as low as possible.

The experiments were started mid November. The ambient temperature varied from 14 °C to 16 °C.

*p*H and conductivity (microSiemens/cm) measurements were taken after a three weeks interval and gave following results:

pine litter	salt concentration	mean and standard deviation of the conductivity (μS/cm)	
		$\bar{x}$	s (= 6)
fresh	control	247	32
	very low	274	26
	medium	475	30
	high	915	61
one year old	control	195	14
	very low	268	13
	medium	445	32
	high	845	62

For the whole of the observation period and the different modalities the *p*H varied from 4.1 to 4.7 only.

The mites were collected by means of a modified Tullgren funnel. The volume of the samples was 100 ml substrate. Sampling was carried out after 1.5 and 3.5 months. Ten replicates were taken, the total number of samples being 160 (2 types of substrate × 2 periods × 4 salt contents × 10 replicates).

For the applied nomenclature is referred to the following authors: **Gamasina:** KARG, W., 1971; **Uropodina:** HIRSCHMANN, W., 1957—1978; **Oribatei:** WILLMANN, C., 1931; SELLNICK, M., 1960; **Acaridiae:** HUGHES, A. M., 1976; TÜRK, E. & F. 1957; SCHEUCHER, R., 1957; **Tarsonemini:** KRCZÁL, H., 1959; KARAFIAT, H., 1959; SCHAARSCHMIDT, L., 1959; **Prostigmata:** THOR, S., & WILLMANN, C., 1947; THOR, S., 1933; KRANTZ, G. W., 1978; SUMMERS, F. M., 1962.

4. Results

4.1. Population composition

For the 160 samples of 100 ml a total of 15,365 mites were counted. Table 1 gives the composition in family-groups according to substrate and time of sampling.

For most groups the faunistic composition has been established, it is given in Tables 2, 3 and 4. The same tables also give the number of mites found at different salt concentrations. A survey of the mesostigmatic fauna is given in Table 2. Some species were strikingly dominant. Well represented in fresh pine litter were *Pergamasus* nymphs (28 %), *Pergamasus vagabundus* (22 %), *Pergamasus conus* (20 %) and *Veigaia nemorensis* (7 %). The Uropodina were represented mainly by *Uropoda minima* (16 %). In one year pine litter *Uropoda minima* composed more than half (52 %) of the total Mesostigmatid population, followed by *Veigaia nemorensis* (28 %) and *Pergamasus* nymphs (10 %).

Table 1. Number of Acari according to family-groups, substrate and period

	Substrate		Time of sampling	
	fresh pine litter	one year old pine litter	after 40 days	after 100 days
Gamasina	638	479	737	380
Uropodina	128	538	361	305
Prostigmata	233	389	228	394
Tarsonemini	1,010	73	533	550
Acaridiae	713	575	862	426
Oribatei	7,746	2,483	6,828	3,401
Juveniles (x)	169	191	247	113
Total	**10,636**	**4,728**	**9,796**	**5,569**
Average/100 ml	133.0	59.1	122.5	69.6

(x) Not yet identifiable (mostly larvae).

From Table 1 can be concluded:

(1) fresh pine litter contains more mites than one year old litter (133 : 59) per 100 ml substrate);
(2) the Oribatei constitute the largest group, they represent 73 % of the total number of mites in the fresh pine litter and 53 % in the litter one year old;
(3) Uropodina and Prostigmata only are more numerous in one year old litter than in the fresh one;
(4) with the exception of Prostigmata and Tarsonemini, all groups are better represented at the start of the experiment.

Two facts emerge from a comparison of the sampling periods:

1. in the second period *Pergamasus nymphs* practically vanished;
2. *Uropoda minima*, *Veigaia nemorensis* and *Pergamasus conus* showed a relative increase; for the first two this was apparently a normal phenomenon since they are typical inhabitants of older litter.

The increase in the observed numbers of *Pergamasus conus* can be explained by the development of unidentifiable nymphs into adults.

Population variations due to changes in salt concentration are discussed farther on.

The faunistic composition of the Prostigmata, Tarsonemini and Acaridiae is given in Table 3.

Table 2. Numbers of Mesostigmata according to substrate 40 and 100 days after application of the fertilizer, and different salt concentrations

	Substrate		Period		Salt concentration			
	F	0	40	100	n	l	m	h
Gamasina								
Evimirus uropodinus	3	17	10	10	10	4	6	—
Parholaspulus alstoni	—	5	—	5	1	1	1	2
Macrocheles penicilliger	—	4	1	3	2	—	—	2
Pachylaelaps longisetis	—	2	1	1	—	—	1	1
Pachylaelaps pectinifer	—	2	1	1	—	1	—	1
Geholaspis mandibularis	—	4	4	—	—	1	2	1
Hypoaspis aculeifer	11	—	—	11	5	2	—	4
Zerconopsis remiger	—	1	1	—	—	—	1	—
Dendrolaelaps reticulosus	1	—	1	—	1	—	—	—
Pergamasus quisquiliarum	1	—	1	—	—	1	—	—
Pergamasus crassipes	1	—	1	—	—	—	1	—
Pergamasus septentrionalis	1	1	2	—	—	1	—	1
Pergamasus robustus	22	3	24	1	10	8	5	2
Pergamasus conus	152	9	65	96	57	79	21	4
Pergamasus vagabundus	170	36	139	67	78	77	44	7
Pergamasus nymphs	212	104	313	3	97	132	51	36
Parasitus insignis	1	4	5	—	1	—	3	1
Veigaia kochi	9	1	3	7	8	1	1	—
Veigaia nemorensis	54	286	165	175	104	113	71	52
Uropodina								
Trachytes aegrota	2	7	9	—	3	4	2	—
Uropoda minima	125	531	351	305	243	194	149	70
Trichouropoda obscura	1	—	1	—	—	1	—	—
Total number	**766**	**1,017**	**1,098**	**685**	**620**	**620**	**359**	**184**

Note: Fresh pine litter substrate (F); pine litter one year old (0). Different salt concentrations: nil (e), very low (l), moderate (m) and high (h).

Table 3. Numbers of Prostigmata, Tarsonemini and Acaridiae according to substrate 40 and 100 days after application of the fertilizer, and different salt concentrations

	Substrate		Period		Salt concentration			
	F	0	40	100	n	l	m	h
Prostigmata								
Raphignathidae (1)	5	1	6	—	1	3	1	1
Rhagidiidae	169	16	56	129	68	65	18	34
Ereynetidae	36	4	28	12	12	11	5	12
Pachygnathidae (2)	23	368	138	253	145	88	89	69
Tarsonemini								
Scutacaridae	914	44	470	488	276	266	156	260
Pyemotidae	78	9	54	33	27	29	14	17
Tarsonemidae	17	20	9	28	8	3	8	18
Acaridiae								
Caloglyphus sp.	130	122	173	79	31	91	38	92
Schrichea sp.	336	15	234	117	127	105	60	59
Tyrophagus sp.	21	12	31	2	13	8	8	4
Anoetidae (3)	226	412	413	225	159	113	240	126
Others	1	14	11	4	7	4	4	—
Total number	**1,956**	**1,037**	**1,623**	**1,370**	**874**	**786**	**641**	**692**

(1) a.o. *Stigmaeus* sp.
(2) a.o. *Bimichaelia* sp.
(3) a.o. *Histiostoma* sp.

Note: Fresh pine litter (F); pine litter one year old (0). Different salt concentrations: nil (e), very low (l), moderate (m) and high (h).

Table 4. Number of Oribatei according to substrate 10 and 100 days after application of the fertilizer and salt concentrations

	Substrate		Period		Salt concentration			
	F	0	10	100	n	l	m	h
Oribatei								
Steganacarus striculus	1,925	572	1,232	1,265	616	691	505	685
Phthiracarus nitens	2	—	2	—	1	1	—	—
Rhysotritia duplicata	17	68	58	27	36	23	18	8
Microtritia minima	42	2	15	29	14	16	4	10
Hypochthonius minutissimus	8	1	6	3	2	3	1	3
Hypochthonius rufulus	65	2	44	23	14	16	11	26
Liochthonius perpusillus	845	220	601	464	404	375	151	135
Nothrus silvestris	88	40	90	38	55	31	28	14
Trypochthonius sp.	54	—	44	10	15	3	18	18
Camisia segnis	9	5	9	5	4	4	4	2
Camisia spinifer	18	7	15	10	3	13	7	2
Platynothrus peltifer	496	35	421	110	155	204	94	78
Adoristes ovatus	31	5	31	5	10	14	9	3
Tectocepheus velatus	3,135	680	3,066	749	1,043	1,382	694	696
Odontocepheus elongatus	4	12	12	4	4	3	3	6
Cepheus cepheiformis	1	9	9	1	2	2	3	3
Belbidae (*Damaeus* sp. + *Belba* sp.)	1	10	7	4	5	3	—	3
Suctobelba subtrigona	520	122	387	255	196	220	104	122
Oribella lanceolata	158	362	302	218	69	156	149	146
Oppia sp.	260	295	419	136	136	177	149	93
Scheloribates latipes	20	14	17	17	5	10	10	9
Chamobates schützi	10	5	5	10	3	10	—	2
Trichoribates trimaculatus	16	7	14	9	3	8	6	6
Pergalumna nervosus	21	10	22	9	3	7	8	13
Total number	**7,746**	**2,483**	**6.828**	**3,401**	**2,798**	**3,372**	**1,976**	**2,083**

Note: Fresh pine litter (F); pine litter one year old (0). Different salt concentrations: nil (c), very low (l), moderate (m) and high (h).

Dominant in fresh pine litter were the Scutacaridae with 47 %. In one year litter Anoetidae (40 %) and Pachygnathidae (35 %) were dominant. The latter (especially *Bimichaelia*) and the Rhagidiidae increased strikingly during the second period.

Table 4 gives the proportional distribution of Oribatei species. Dominant species in fresh pine litter were *Tectocepheus velatus* (40 %), *Steganacarus striculus* (25 %), *Liochthonius perpusillus* (11 %), *Suctobelba subtrigona* (7 %) and *Platynothrus peltifer* (6 %). In one year old pine litter *Tectocepheus velatus* (27 %) and *Steganacarus striculus* (23 %) were again most numerous, but *Oribella lanceolata* (15 %), *Oppia* species (12 %) and *Liochthonius perpusillus* (9 %) formed a significant proportion of the total oribatid population.

4.2. Distribution

The distribution of the most common mites in the substrate is given in Table 5.

In the soil, mites are almost always found in "aggregates". Recently Usher (1969, 1975) and Usher & Hider (1975) studied the aggregation of Collembola. Pronounced aggregation by collembola, mites and enchytraeids could be observed in all our experiments.

In pine litter earthworms only exhibited a "Poisson distribution". The presence of soil organisms in aggregates is demonstrated by the correlation formula $s^2/\bar{x} > 1$ (Debauche 1958, 1962; Andrewartha 1961; Healy 1962; Cancela da Fonseca 1965, 1966), which can be assessed by the hypothesis $s^2 = \bar{x}$. The t test for (n 1) degrees of freedom after Greig-Smith (1964) (see Table 5) demonstrates for the best represented mites a very high probability (> 0,001), which permits acceptance of the existence of a pronounced "aggregation".

Table 5. Ratio of the most representative mites in the 160 samples of 100 ml of substrate

	Arithmetical mean $\bar{x}$	Variance s^2	$s^2/\bar{x}$	Greig-Smith-assay $t = \frac{\frac{s^2}{\bar{x}} - 1}{\sqrt{\frac{2}{n-1}}}$
Pergamasus conus	1.006	5.30	5.268	38.055
Pergamasus vagabundus	1.288	4.94	3.835	25.278
Veigaia nemorensis	2.144	6.94	3.237	19.946
Juvenile Gamasina	1.994	12.08	6.058	45.099
Uropoda minima	4.106	18.60	4.530	31.474
Rhagidiidae	1.156	4.42	3.824	25.180
Pachygnathidae	2.444	12.27	5.020	35.843
Scutacaridae	5.994	60.60	10.110	81.227
Pyemotidae	0.544	1.81	3.327	20.748
Caloglyphus sp.	1.575	8.42	5.346	38.750
Schwiebea sp.	2.194	15.40	7.019	53.667
Anoetidae	3.988	22.57	5.659	41.541
Steganacarus striculus	15.606	137.25	8.795	69.502
Rhysotritia duplicata	0.531	0.82	1.544	4.850
Liochthonius perpusillus	6.594	58.70	8.902	70.456
Nothrus silvestris	0.800	5.59	6.988	53.391
Platynothrus peltifer	3.319	25.83	7.782	60.470
Tectocepheus velatus	23.844	795.81	33.376	288.673
Suctobelba subtrigona	4.006	26.08	6.510	49.129
Oribella lanceolata	3.250	11.25	3.462	21.952
Oppia spp.	3.469	12.69	3.658	23.699

4.3. Analysis of variance

Although the data given in Tables 2, 3 and 4 permit an interpretation of the influence on the mite fauna of the substrate, elapsed time and the salt concentration, statistical evidence is not directly obtainable from them. However the influence of each of the different factors appears clearly from the analysis of variance.

In case of "aggregation" the analysis of variance requires a transformation to normally distributed numbers. The former was done on scores per 100 ml substrate transformed to $\log (x + 1)$. The different sources of variation are substrate (type of litter), period and salt concentration and further, the possible interactions between these 3 factors.

For the most representative mite species the mean squares of deviation are given in Table 6.

From this table can be concluded that the most important source of variation was the type of litter (fresh pine litter substrate or one year old pine litter). This was so for 13 of the 18 mite species (genera, families). For *Steganacarus* and the Anoetidae the influence of the period and of the substrate were equal. For the remaining 3 acarid groups, namely the juvenile Gamasina, *Caloglyphus* and *Oppia*, the period (sampling 40 or 100 days after treatment) was the only dominant factor.

In none of these cases was the salt concentration the most important factor in the population density.

Table 7 gives the calculated F-values after analysis of variance and the confidence level for the different sources of variation.

The influence of the substrate was significant for 16 of the 18 most representative mite species as compared with only 10 out of 18 influenced by the period.

The F-values for the salt concentration are smaller than for the substrate and period, nevertheless, the salt concentration was a significant source of variation for 17 of the species. Many interaction factors were significant, especially "litter - salt concentration" which makes the interpretation less easy. This will be considered when the influence of the salt concentration is discussed.

Table 6. The mean squares after analysis of variance

Source of variation	L	P	Sc	L × P	L × Sc	P × Sc	L × P × Sc	Residual Error
Degrees of freedom	1	1	3	1	3	3	3	144
Pergamasus conus	3.4516	0.1288	0.6367	0.1092	0.3584	0.1012	0.0090	0.0387
Pergamasus vagabundus	2.5756	0.4687	0.7668	0.4862	0.2917	0.1148	0.0655	0.0453
Veigaia nemorensis	6.4320	0.0608	0.2171	0.0141	0.0987	0.1074	0.1239	0.0601
Juvenile Gamasina	1.0002	10.5527	0.5113	0.6112	0.0976	0.4959	0.0679	0.0537
Uropoda minima	7.6257	0.1911	1.2396	0.0508	0.7032	0.0538	0.0653	0.0581
Rhagidiidae	3.7946	0.3460	0.2489	0.6811	0.2534	0.1265	0.1158	0.0488
Pachygnathidae	13.5897	0.3142	0.1947	0.3249	0.0617	0.0284	0.0644	0.0455
Scutacaridae	27.2333	0.1482	0.5371	0.0098	0.4457	0.1588	0.1866	0.0832
Caloglyphus sp.	0.0024	1.3451	0.2489	0.0005	0.4148	0.0565	0.0116	0.0801
Schwiebea sp.	10.1707	0.7562	0.3713	0.3098	0.6292	0.0675	0.0817	0.0618
Anoetidae	2.1183	1.8988	0.2347	0.3506	0.5820	0.0554	0.0874	0.1146
Steganacarus striculus	8.4916	0.2592	0.2794	0.2295	0.6938	0.1502	0.1659	0.0711
Liochthonius perpusillus	6.6016	0.2880	1.5262	0.0656	0.9799	0.1479	0.1591	0.1105
Platynothrus peltifer	13.9417	3.4018	0.3158	1.7243	0.3625	0.0927	0.0065	0.0443
Tectocepheus velatus	11.6532	12.4993	0.8627	0.2907	0.7597	0.0098	0.0967	0.0593
Suctobelba subtrigona	5.9946	0.0252	0.4061	0.5279	0.6245	0.3121	0.3063	0.0877
Oribella lanceolata	2.2801	0.1232	0.6020	0.1690	0.7302	0.4306	0.3440	0.0709
Oppia spp.	0.1000	4.8233	0.3199	0.2512	0.1225	0.0700	0.0118	0.0769

Note: Transformation: log (x + 1).
L = type of litter; P = period; Sc = salt concentration

Table 7. Calculated F-values after analysis of variance

Source of variation	L	P	Sc	L × P	L × Sc	P × Sc	L × P × Sc
Pergamasus conus	89.19**	3.33	16.45**	2.82	9.26**	2.61	0.23
Pergamasus vagabundus	58.86**	10.35**	16.93**	10.73**	6.44**	2.53	1.45
Veigaia nemorensis	107.02**	1.01	3.61*	0.23	1.64	1.79	2.06
Juvenile Gamasina	18.63**	196.51**	9.52**	11.38**	1.82	9.23**	1.26
Uropoda minima	131.25**	3.29	21.34**	0.87	12.10**	0.93	1.12
Rhagidiidae	77.76**	7.09**	5.10**	13.96**	5.19**	2.59	2.37
Pachygnathidae	298.67**	6.91**	4.28**	7.14**	1.36	0.62	1.42
Scutacaridae	327.32**	1.78	6.46**	0.12	5.36**	1.91	2.24
Caloglyphus sp.	0.03	16.79**	3.11*	0.01	5.18**	0.71	0.14
Schwiebea sp.	164.57**	12.24**	6.01**	5.01*	10.18**	1.09	1.32
Anoetidae	18.48**	16.57**	2.05	3.06	5.08**	0.48	0.76
Steganacarus striculus	119.43**	3.65	3.93**	3.23	9.76**	2.11	2.33
Liochthonius perpusillus	59.74**	2.62	13.81**	0.59	8.87**	1.34	1.44
Platynothrus peltifer	314.71**	76.79**	7.13**	38.92**	8.18**	2.09	0.15
Tectocepheus velatus	196.51**	210.78**	14.55**	4.90*	12.81**	0.17	1.63
Suctobelba subtrigona	68.35**	0.29	4.63**	6.02*	7.12**	3.56*	3.49*
Oribella lanceolata	32.16**	1.74	8.49**	2.38	10.30**	6.07**	4.85**
Oppia spp.	1.30	62.72**	4.16**	3.27	1.59	0.91	0.14

Note: The difference is significant at 95 % confidence level (*) or 99 % (**).
L = type of litter; P = period; Sc = salt concentration

Table 8. Logarithmic mean [1/n Σ log (x + 1)] per 100 ml substrate in the different modalities of the salt concentration

	control	very low	moderate	high	L.S.D. (**)
Pergamasus conus	0.271	0.294	0.125	0.027	0.115
Pergamasus vagabundus	0.364	0.318	0.208	0.053	0.126
Veigaia nemorensis	0.415	0.450	0.331	0.290	0.144
Juvenile Gamasina	0.323	0.410	0.201	0.163	0.133
Uropoda minima	0.714	0.681	0.490	0.337	0.141
Rhagidiidae	0.269	0.266	0.102	0.193	0.128
Pachygnathidae	0.468	0.360	0.343	0.305	0.126
Scutacaridae	0.632	0.606	0.379	0.582	0.170
Caloglyphus sp.	0.189	0.317	0.231	0.362	0.165
Schwiebea sp.	0.394	0.354	0.176	0.275	0.147
Anoetidae	0.564	0.449	0.622	0.492	0.199
Steganacarus striculus	1.109	1.160	0.965	1.099	0.157
Liochthonius perpusillus	0.877	0.792	0.520	0.485	0.194
Plathynothrus peltifer	0.461	0.515	0.351	0.328	0.123
Tectocepheus velatus	1.202	1.322	1.014	1.031	0.144
Suctobelba subtrigona	0.543	0.654	0.421	0.473	0.173
Oribella lanceolata	0.319	0.597	0.535	0.544	0.157
Oppia spp.	0.560	0.616	0.525	0.405	0.162

L.S.D. (**) least significant difference for the confidence level 99%

Interactions caused by commensalism, antagonism, predation and competition are difficult to assess in a biotope as rich as the one here studied.

4.4. Influence of substrate (type of litter) and period of sampling on the population density

A combination of the data from tables 2, 3 and 4 together with table 7 permit statistical conclusions to be drawn about the size of the populations in the two types of substrate and during the two periods.

It can be concluded from table 7 that *Caloglyphus* sp. and *Oppia* spp. were only an insignificant proportion of the populations in both substrates.

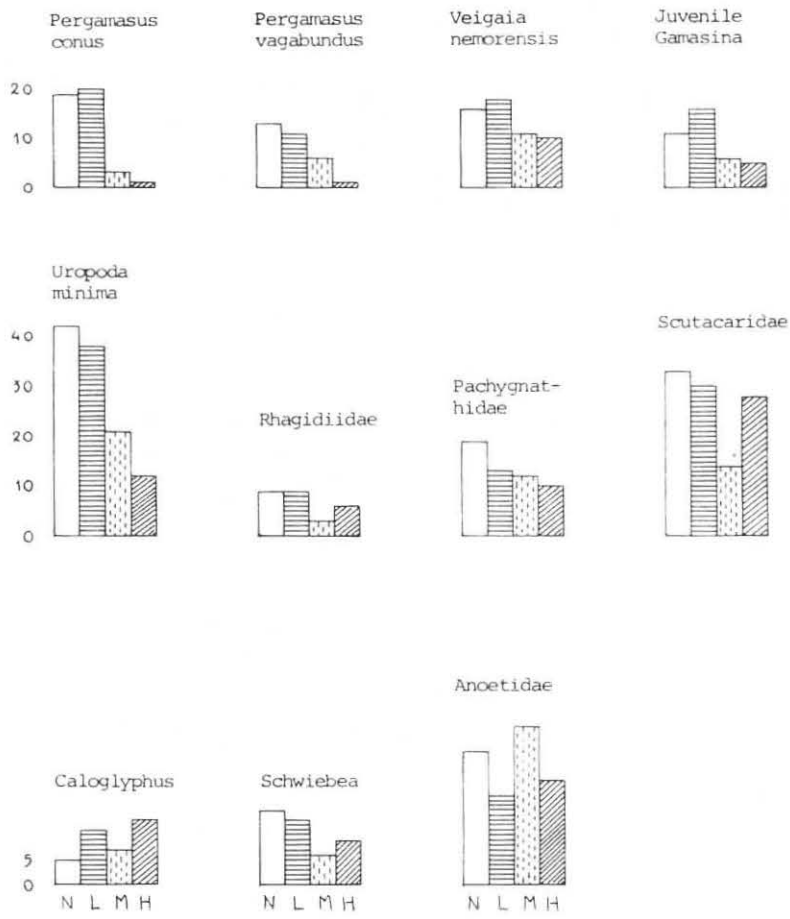
However it is clear that in general at the first sampling (40 days after treatment) a greater number of mites was counted than at the second sampling (after 100 days). The observed species of the Rhagidiidae and Pachygnathidae were an exception, and showed a significant increase at the second sampling.

4.5. Influence of the salt concentration (conductivity) on the population density

The significant differences in population density according to salt concentration can be deduced from the data given in Table 8. The population density of the different mites is further illustrated graphically in figures 1 a and 1 b.

For the Mesostigmata no significant difference can be observed between the nil and a low salt concentration. However between low, moderate and high salt concentrations significant differences are clearly present. The population of *Pergamasus*, *Veigaia* and Uropodina decreases with increasing salt concentration. This applies most notably (probability > 0.01) for *Uropoda minima* and the genus *Pergamasus* (most of the Juvenile Gamasina were *Pergamasus* nymphs). For *Veigaia nemorensis* however a less pronounced significant difference is noted. It can be suggested that the typical Mesostigmata fauna from pine litter is adversely affected by an increased salt concentration. The *Pergamasus* population (*P. vagabundus* and *P. conus*) could even present a certain value as an indicator of salt concentration.

Recent research (Heungens 1980) proved that increased salt contents are very toxic to enchytraeids. If the above-mentioned *Pergamasus* species are effective predators of enchytraeids, we can attribute their population decrease by the disappearance of their prey.



1a

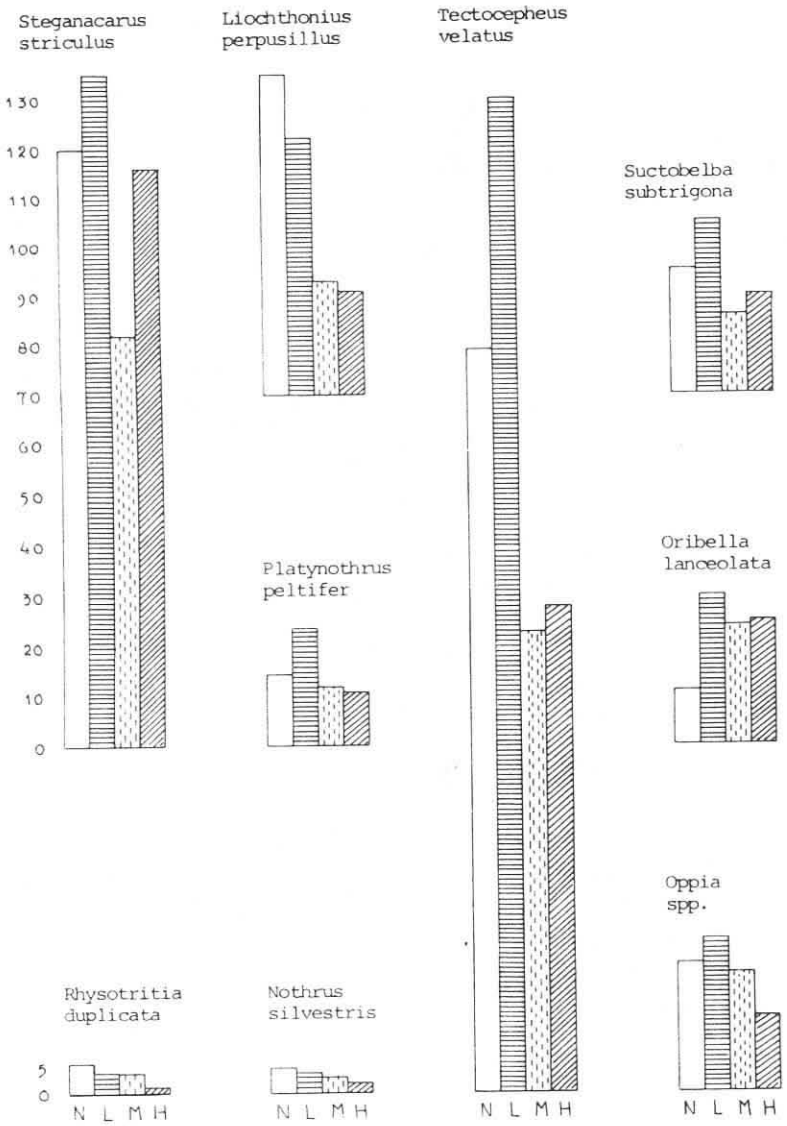
Fig. 1a + b. Average number per liter of different mite species. These data are the retransformed values, which give a good evaluation of the real mean. Variants: Salt concentration nil (N), very low (L), moderate (M) and high (H).

Although positive conclusions can not easely be drawn about the influence of the salt concentration on the observed Rhagidiidae and Pachygnathidae, the populations of these two groups tend to decrease with increasing salt concentration. With regard to the Scutacaridae, it can not be fully explained why at "moderate salt concentration" a significant fewer number of these mites is observed.

Interactions could eventually prove to be the cause. If the predators or antagonists tolerate a moderate but not a high concentration, the Scutacaridae, which as seems to be here are salt tolerant, will undergo a population decrease at the moderate concentration but not at the high one. On the other hand, at a high salt concentration they will have less competition from salt sensitive species.

Using the same dose of fertilizer as the highest in the present experiment (but applied in three periods) Żyromska-Rudzka (1979) obtained a pronounced decrease in numbers of Scutacaridae. However the observation period of this experiment lasted much longer.

Pinus litter was the substrate in our experiment, whereas the research by Żyromska-Rudzka was conducted in "a meadow overgrown with vegetation belonging to the community Arrhenatheretum mediouropaeum" on a brown slightly gley loam.



1b

Possibly the high organic fraction in *Pinus* substrate acts as a strong buffer, which results in a less drastic decrease of the Scutacaridae population.

The Acaridiae *Caloglyphus* sp. and Anoetidae tolerate higher salt concentrations and we found the highest number of *Caloblyphus* specimens in the highest salt modality. *Schwiebea* sp. acted differently however, the highest number of specimens being counted in the lowest salt concentration.

In general the Oribatei population was not pronouncedly diminished by an increasing salt concentration, although significant differences were observed for some species. Not reacting to changing salt content was *Steganacarus striculus*, *Liochthonius perpusillus*, *Platynothrus peltifer*, *Tectocepheus velatus* and the *Oppia* spp. were present in lesser numbers at the higher doses of fertilizer. Similar counts were found for *Suctobelba subtrigona* whereas *Oribella lanceolata* was pronouncedly non reactive to changes in salt concentration.

Comportments whose causes can not be directly deduced from the results of the analysis of variance could be attributed to relations between the organisms.

Although a high salt concentration does not decrease numbers of the Oribatei population in great measure, it is nevertheless obvious that the number of most of the Oribatei species is to a certain extent reduced by it.

SCHUSTER (1956) suggested that 3 divisions of the Oribatei: the macrophytophages, microphytophages and the non-specialised may be distinguished according to their food.

An enumeration of some of the better known food sources of the reported mites is given below, however it seems difficult to classify them with accuracy according to the above mentioned system.

Various data from literature indicate that *Platynothrus peltifer* is a non-specialised species. This was confirmed by our own observations. We collected this species even from growing leaves of *Azalea* and *Begonia*.

According to BERTHET (1964) it feeds mainly on mould, WALLWORK (1967) considers it to be macrophytophagous and LITTLEWOOD (1969) reared it on algae.

Of *Tectocepheus velatus* too the food is not well known. WALLWORK (1967) classifies it as a principally macrophytophagus species and LEBRUN (1971) supposes it to be non-specialised.

Being only represented in rather low numbers, *Rhysotritia duplicata* and *Nothrus silvestris* are not included in Table 8. They also decrease in numbers with increasing salt content (see Table 4). *Rhysotritia duplicata* is only known as a macrophytophage (LEBRUN 1971). According to PANDE & BERTHET (1973) this species prefers decaying wood to pine needles, which explains it presence in one year old rather than in fresh pine litter.

Nothrus silvestris also is macrophytophagus (VAN DER DRIFT 1951; LEBRUN 1971).

PANDE & BERTHET (1973) supposed that it obtained part of its food from the saprophagous microflora living on the needles. Experiments by SENGBUSH (1954) seem to confirm this. These data could be interpreted as an indication that a higher salt content does not favore the Oribatei, indeed the possible increase of microorganisms other than fungae does not result in a greater food supply, while the fungae themselves develop mainly on the needles during decomposition.

5. Conclusions

The results obtained with two types of pine litter and salt concentration increasing up to 2 g compound mineral fertilizer per litre of substrate suggest that the dominant factor influencing the population density of soil mites in the litter is principally the type of substrate.

The sampling period is also a significant factor, but the length of sampling period can be confined theoretically to a particular stage in the decomposition of the litter (viz. in relation to humification and mineralisation).

Except for *Uropoda minima* and some *Pergamasus*-species, the soil mites in the litter seem to be little affected by high salt concentrations. This could be attributable to the disappearance of their more salt sensitive prey.

The observed Prostigmata, Tarsonemini and Acaridiae are not influenced by a higher salt content, however some Oribatei decrease with an higher content.

6. Summary · Résumé

Analysis of variance of the results of laboratory experiments with two pine litter substrates, two periods of sampling and four doses of a compound chemical fertilizer shows that many of the different soil mite species are influenced by the salinity of the substrates. However the substrate remains the most important determinator of the population composition and its density.

An elevated salinity decreases the typical Mesostigmata-fauna of a pine litter substrate and particularly the *Uropoda minima* and the *Pergamasus vagabundus* and *conus* populations. Populations of some Oribatid mite species also decreased with higher salt concentrations, but the influence was rather low as compared with that of the substrate. A salt concentration up to 2 gram of the compound fertilizer Alkrisal (18—6—12) per liter pine litter substrate had no influence on the population density of the observed Tarsonemini, Prostigmata and Acaridiae.

L'influence de la salinité sur les populations des acariens en litière de pin

L'analyse de la variance des résultats d'essais en laboratoire avec deux substrats de litière de pin, deux périodes de prélèvement d'échantillons et quatre doses d'une fumure chimique composée démontre que plusieurs espèces d'Acariens édaphiques réagissent aux changements dans la salinité du substrat.

Toutefois le substrat même reste néanmoins le plus important facteur de la composition et de la densité de la population. Une salinité élevée fait diminuer la faune typique des Mesostigmates d'un substrat composé de litière de pin, plus spécialement les populations d'*Uropoda minima* et des espèces *Pergamasus vagabundus* et *conus*.

En augmentant la salinité la population de certains Acariens Oribates diminue également, mais comparée à celle dépendant du type de substrat cette diminution est peu exprimée. L'application de l'engrais composé "Alkrisal" (18—6—12) jusqu'a 2 grammes par litre de substrat n'avait point d'influence sur la densité des populations des Tarsonemini, Prostigmata et Acaridiae observés.

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Authors' address: A. Heungens and E. van Daele, Fakulteit van de Landbouwwetenschappen, Coupure 533, B - 9000 Gent, Belgium.